Future Midwestern Landscapes

Randy Bruins and Betsy Smith
ERP Virtual Open House
September 24, 2007
3:00 – 4:30 pm

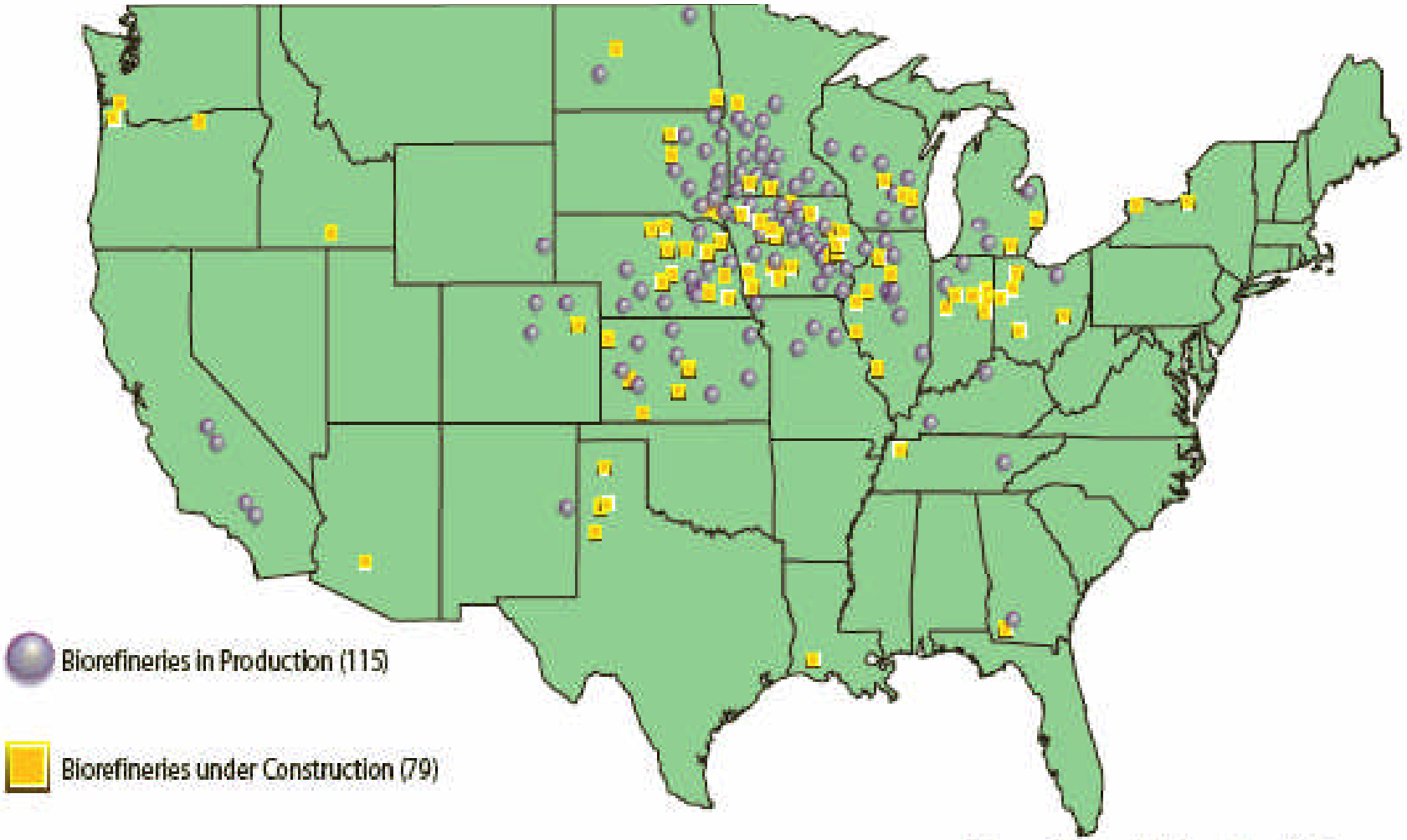
Today's key messages

1. Midwestern landscapes are changing rapidly due to biofuels development, and different future paths appear to offer different eco service profiles
2. FML Study will engage stakeholders, conduct relevant analyses and provide online tools
3. Alternative-futures is our study approach
   - step-by-step, with discussion of methods and needs
4. Our implementation structure will make it easy for you to get involved

Changing landscapes

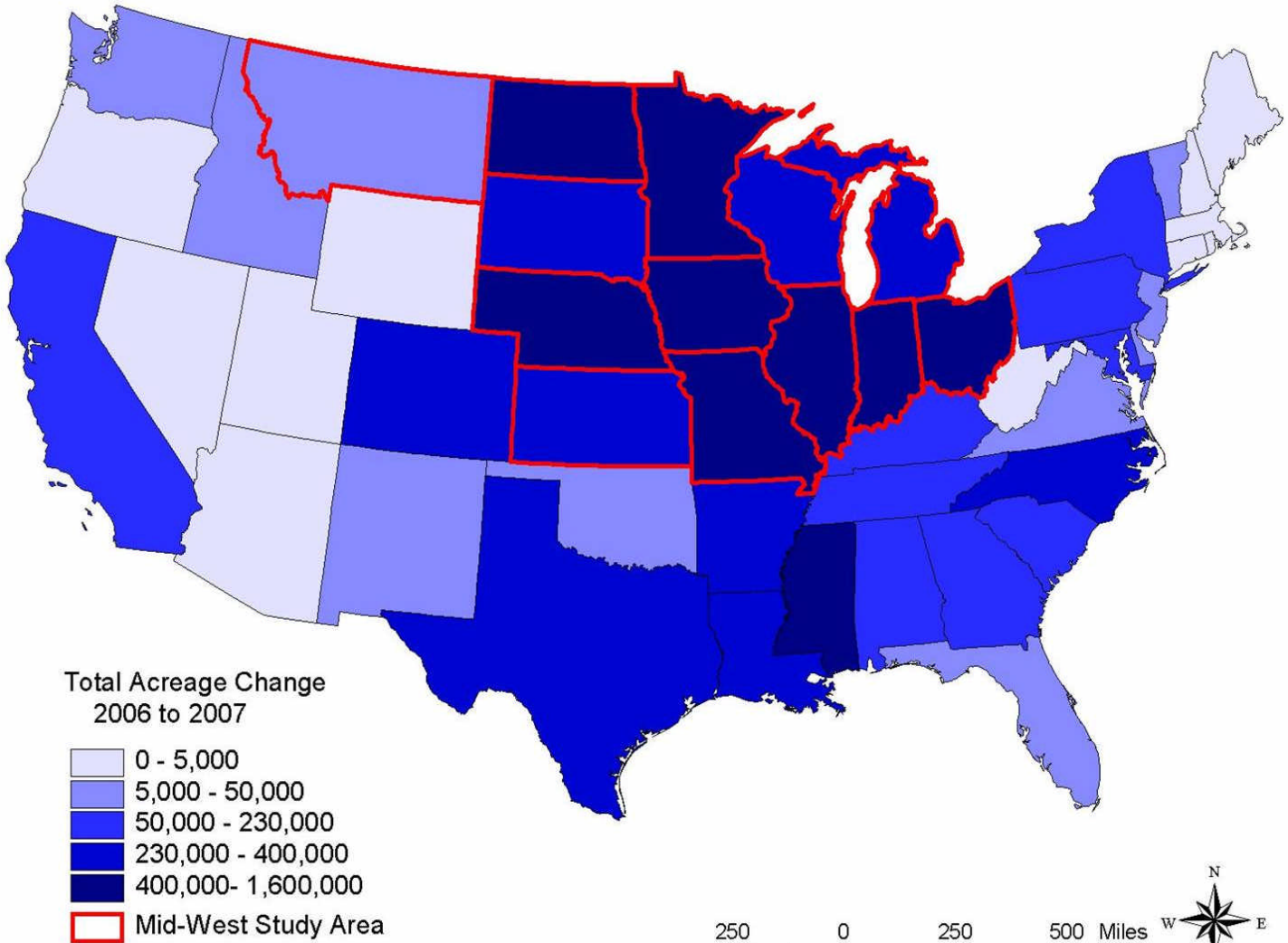
- Administration Goals
  - " 20 in 10" – reduce gasoline usage by 20% in 10 years through mandatory fuels standard requiring 35 billion gallons renewable/alternative fuels in 2017
  - Alternative Energy Initiative: cellulosic ethanol cost-competitive by 2012
- Incentives
  - IRS (tax incentives)
  - USDA and DOE (grant and loan programs)
  - Customs (fuel ethanol import duties)
  - EPA (renewable fuel content standards)
  - State and local incentives

Ethanol Biorefineries (April 2007)



Source: Renewable Fuels Association

Increases in corn plantings for 2007 (FML ecosystem services study area)



Alternative futures…

Low input,
high diversity?

An ecologists' viewpoint…

"Biofuels derived from low-input high-diversity (LIHD) mixtures of native grassland perennials can provide more usable energy, greater greenhouse gas reductions, and less agrichemical pollution per hectare than can corn grain ethanol or soybean biodiesel."

Tilman, D., J. Hill and C. Lehman (2006). "Carbon-negative biofuels from low-input high-diversity grassland biomass." *Science* 314(5805):1598-1600.

Issues study must encompass

Anticipated Benefits

- Improved energy security
- Reduced greenhouse gas emissions
- Rural development
- Improved agricultural sustainability

Concerns

- Questions about overall energy efficiency
- Effects on air, water, soil, health
- Sensitive lands put into production
- Cellulosic ethanol unproven
- Residue removal problematic
- DDG > animal wastes with higher nutrient content
- Higher food prices
- Food oil prices > tropical land conversion

Ecosystem services to be examined

- Soil productivity (affects food and energy security)
- Carbon balance (affects climate)
- Hydrology and water quality (affect water supply, flooding, downstream aquatic ecosystems, recreation)
- Wildlife habitat and other natural areas (affect biodiversity and recreation)
- Predator refugia (controls pests)
- Air quality (affects health and visibility)

Ecosystem services…

- Much of the debate will center on just a few of these services
- Stakeholders want us to bring the rest of the services to the decision table

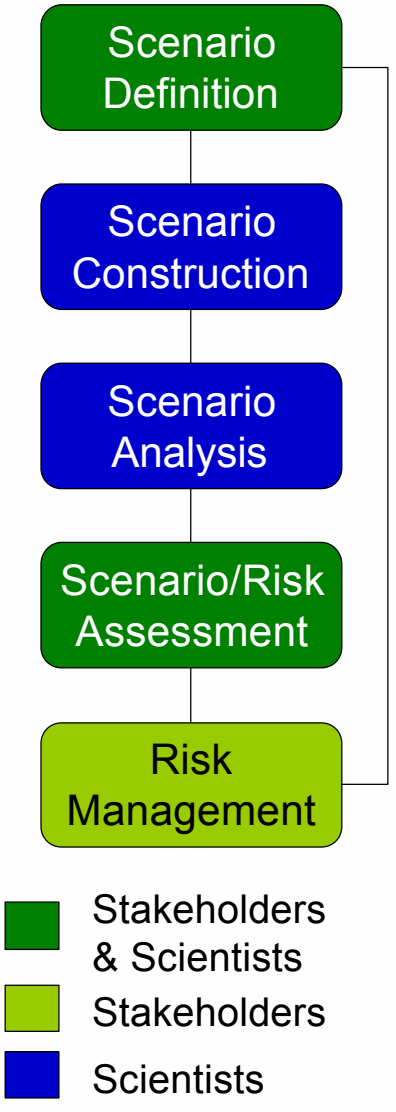
FML Study Goals

- Understand how current and projected land uses affect the **ecosystems services** provided by Midwestern **landscapes**
- Provide **spatially explicit** information that will enable EPA Regions and Programs to articulate sustainable approaches to environmental management
- Develop **web-based tools** depicting alternative futures so users can evaluate trade-offs affecting ecosystem services

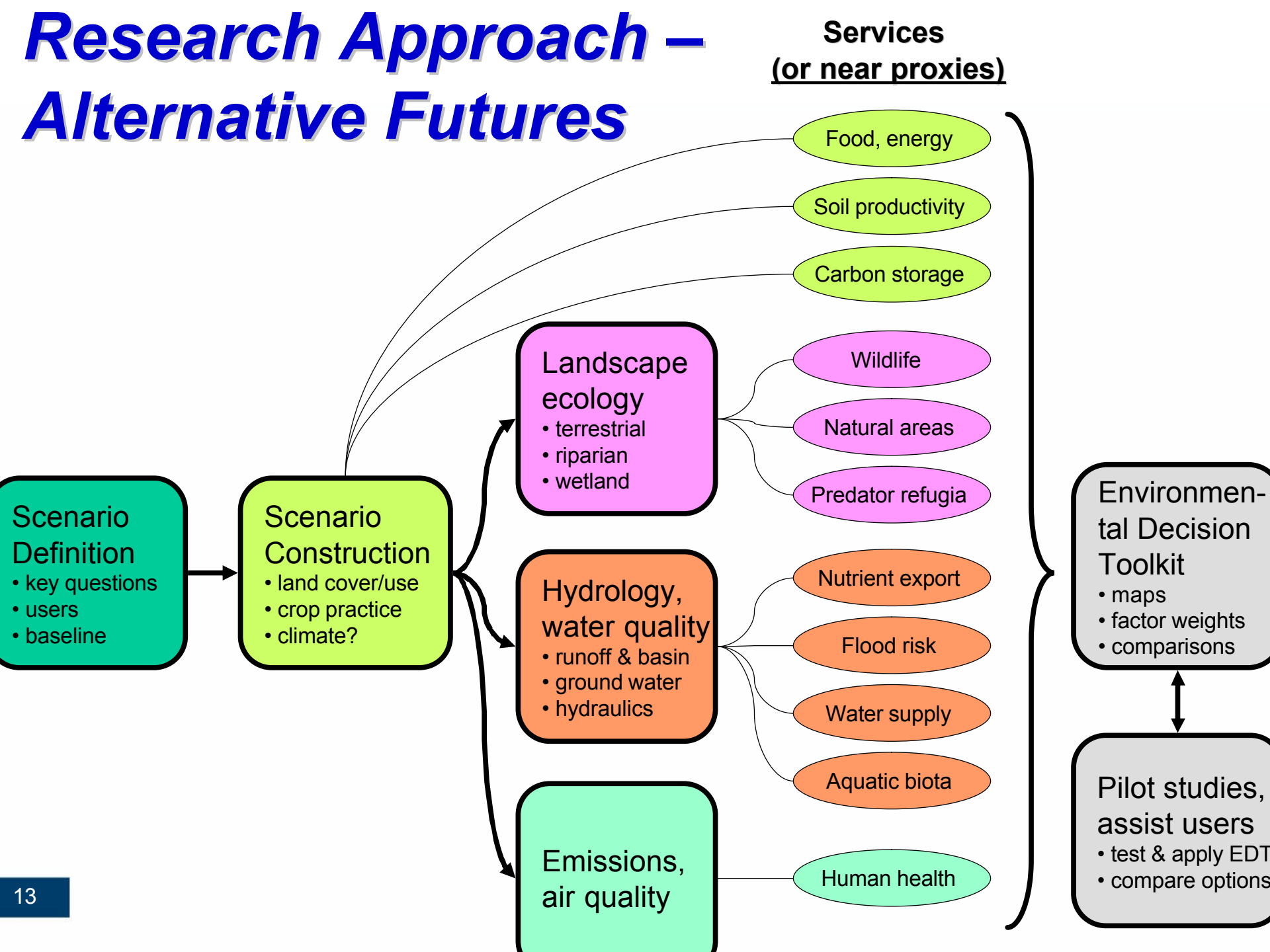
Research Approach – Alternative Futures

Adapted from Liu et al., 2007

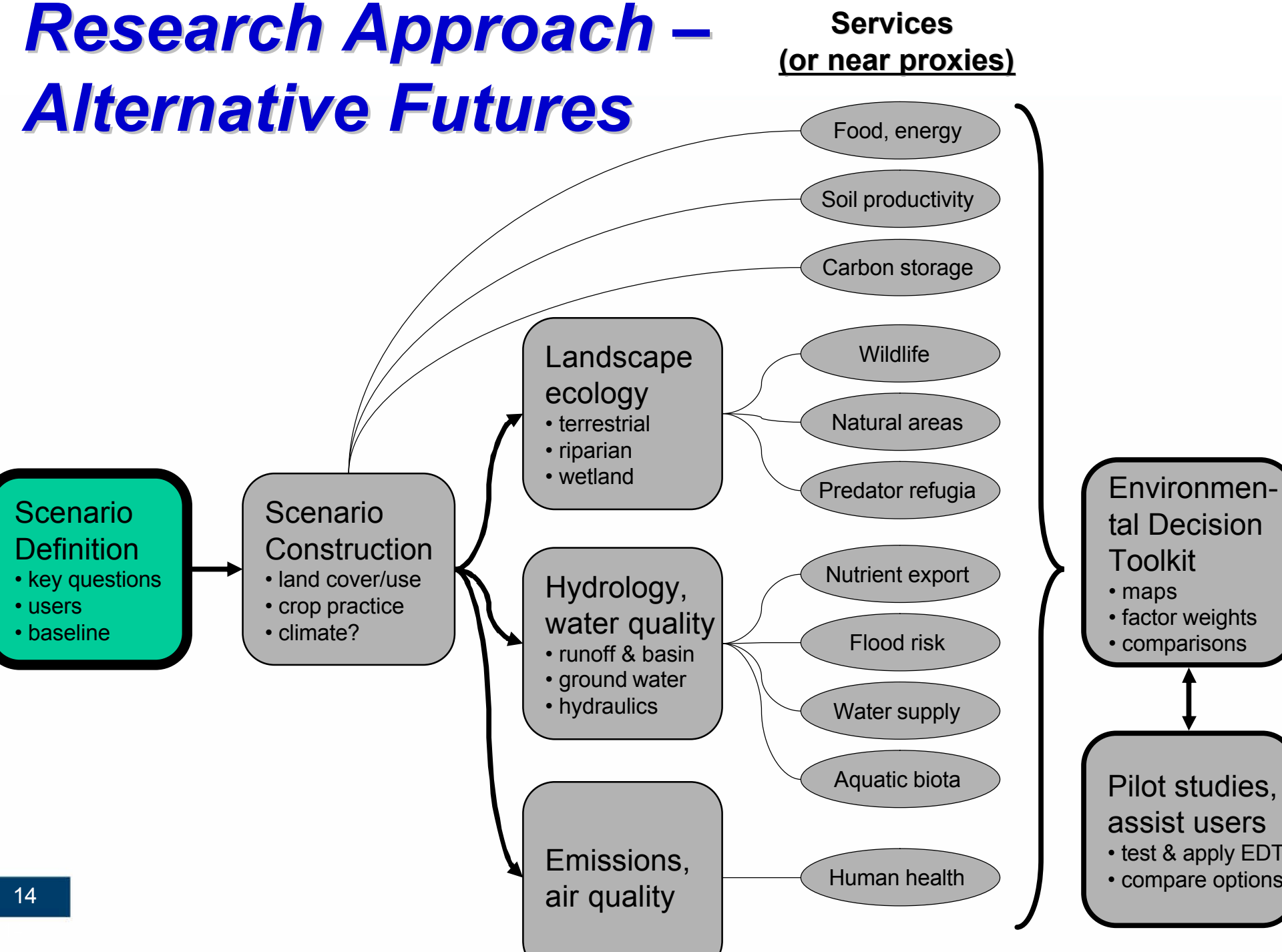
1. **Scenario Definition**
   - Stakeholder meetings will explore values related to alternative futures for the Midwest
2. **Scenario Construction**
   - Future economic drivers and land cover will be modeled for each scenario
3. **Scenario Analysis**
   - Ecosystem services will be modeled and compared to baseline conditions
4. **Scenario/Risk Assessment**
   - Web-based tools will be developed to visualize and present results
5. **Risk Management**
   - Decision makers using these tools will be better informed when choosing courses of action



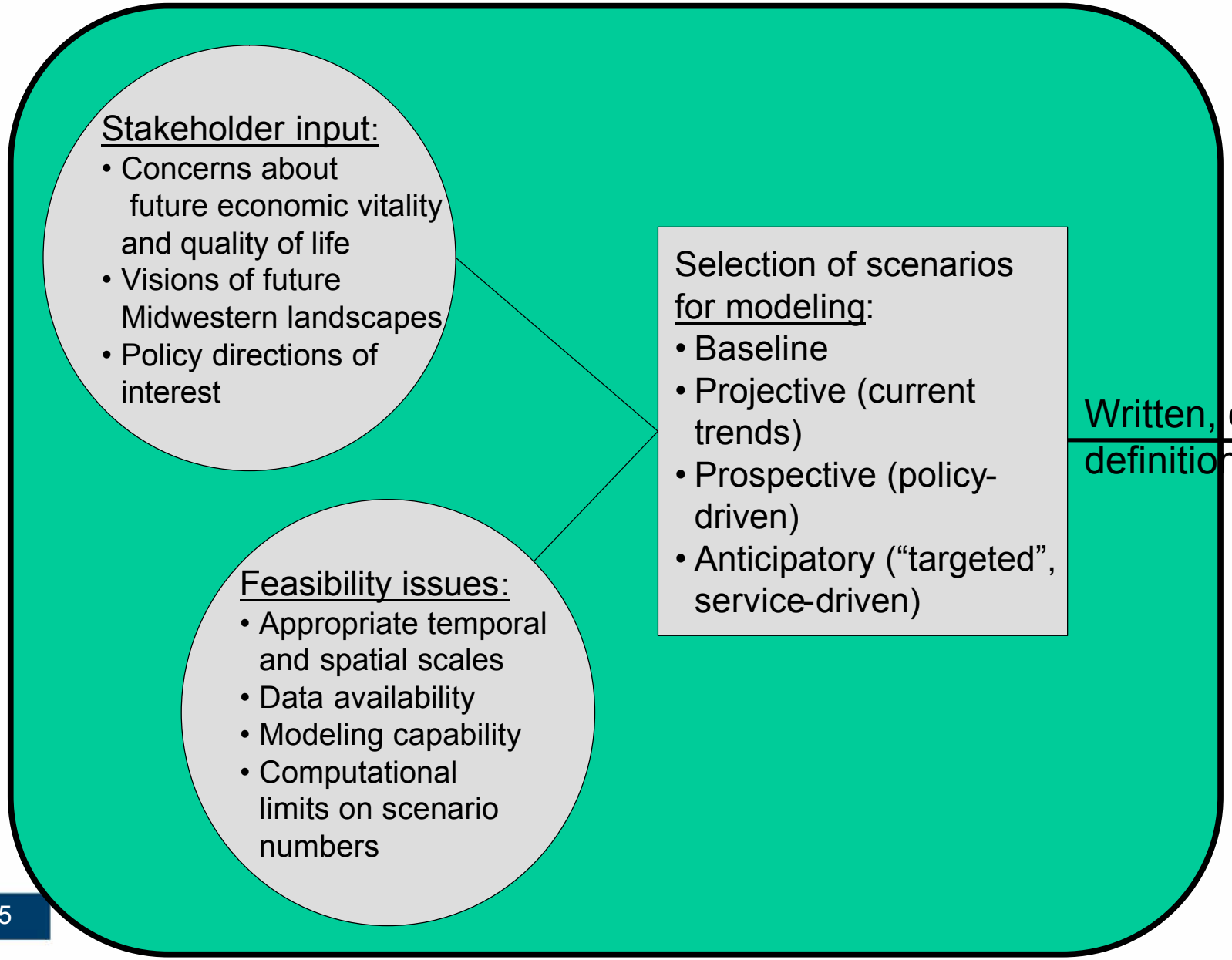
Research Approach – Alternative Futures



Research Approach – Alternative Futures



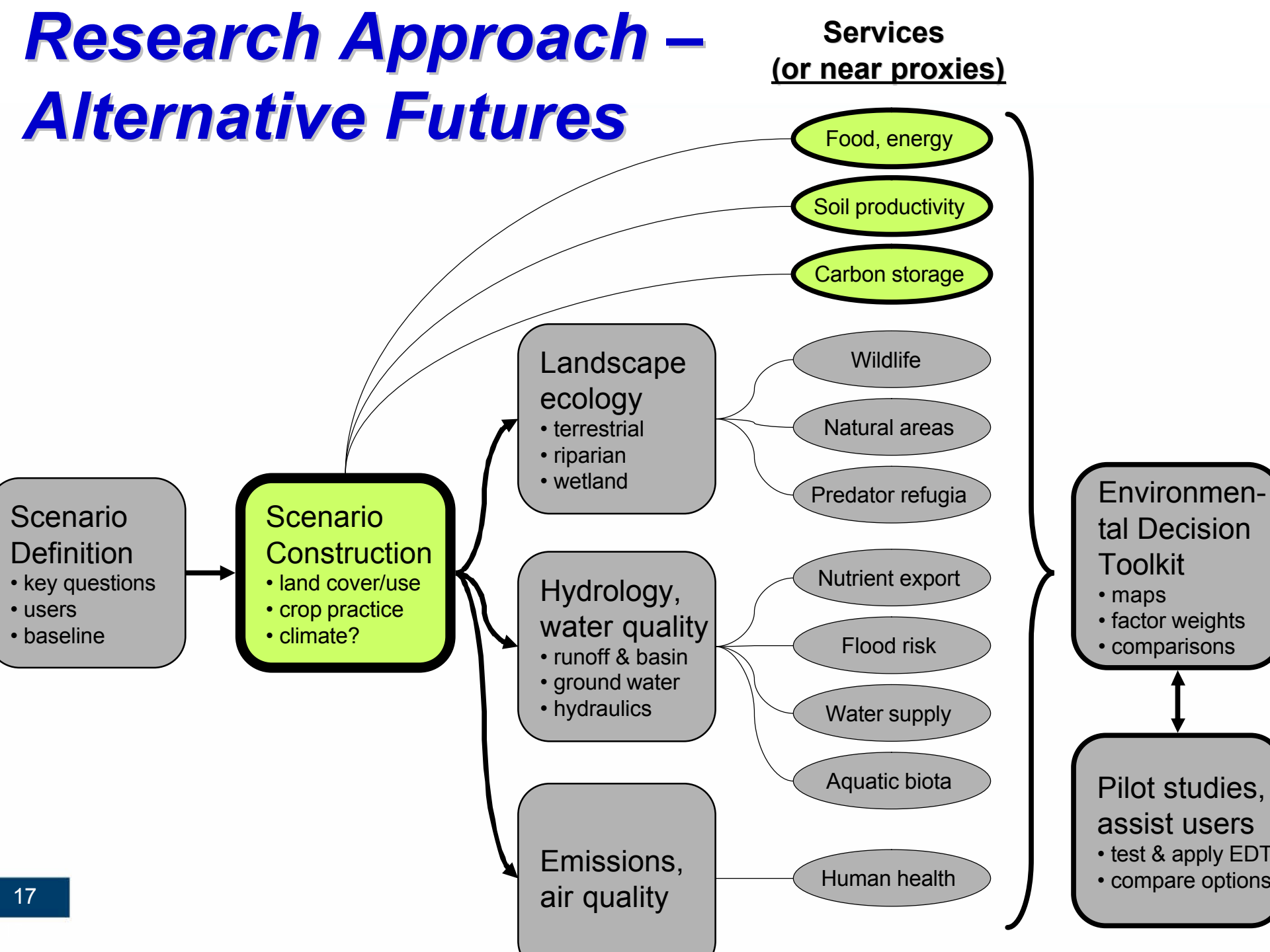
Scenario Definition



Examples of Potential Scenarios

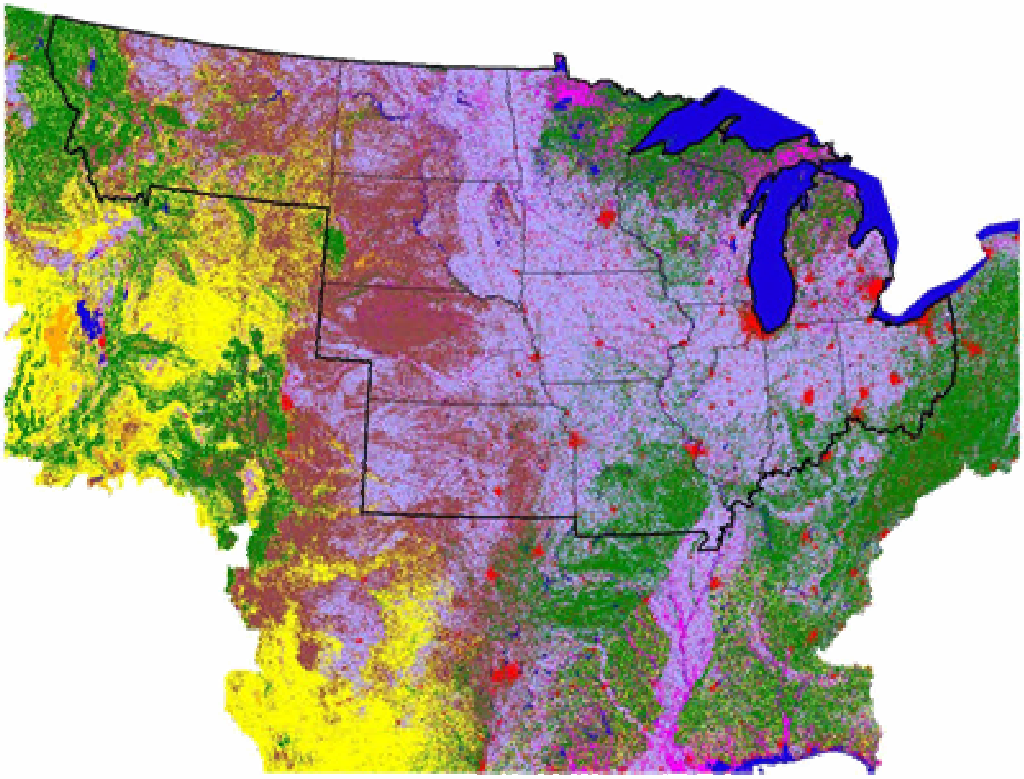
- Historic land cover
  - 2003 - 2005 (*Actual baseline scenario*)
- Land cover based on economic modeling
  - Assume current economic trends, but remove all incentives (*Prospective baseline scenario*)
  - Continue current policies and require increased cellulosic ethanol content (*Prospective policy scenario*)
- Land cover based on agronomic and ecological principles
  - Create landscapes favoring a mix of ecosystem services (*Anticipatory design or "targeting" scenario*)

Research Approach – Alternative Futures

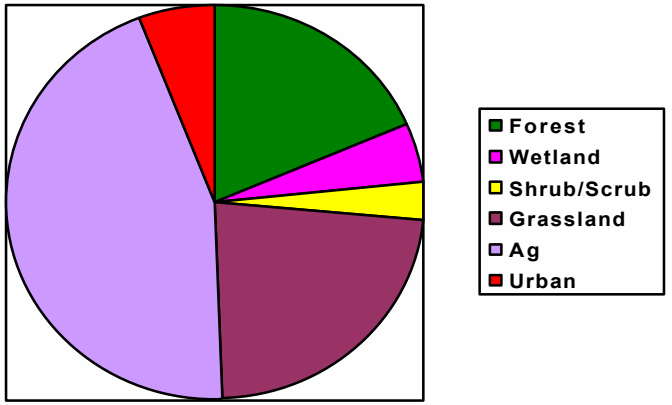


Landscape Change

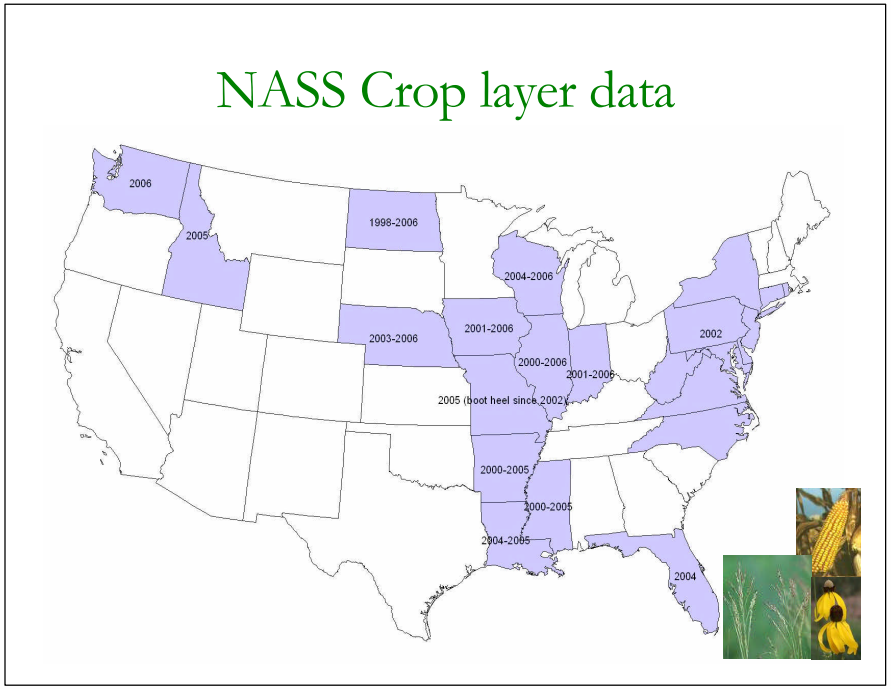
Our starting point: Land Use/ Land Cover across the Midwest



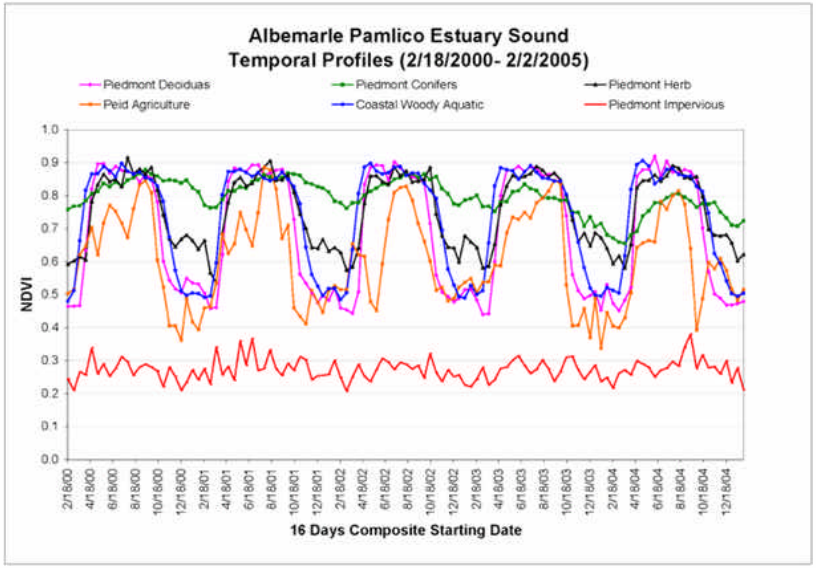
NLCD 2001, 30m resolution



Scenario Construction: Baseline

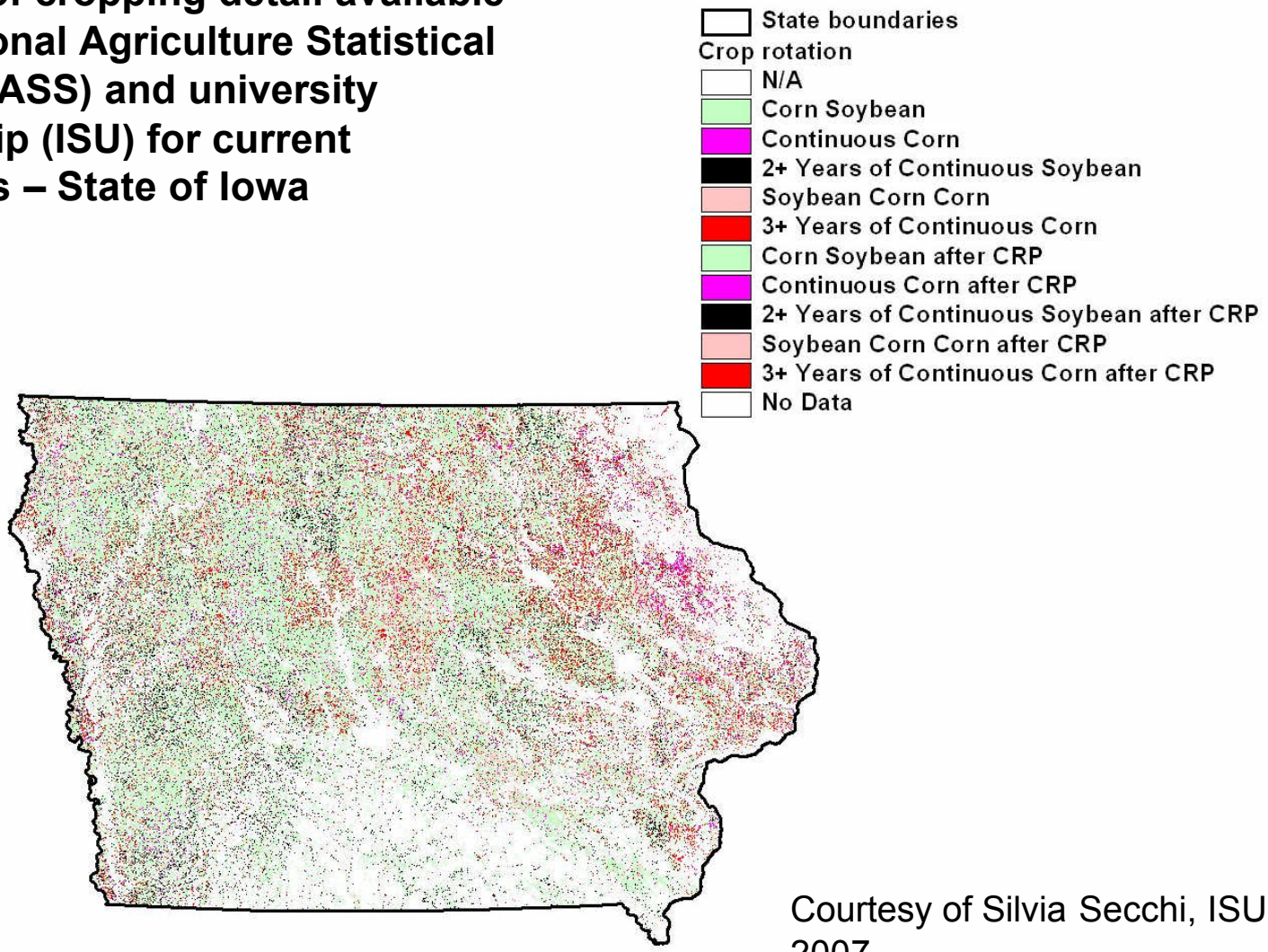


Combination of NASS crop data



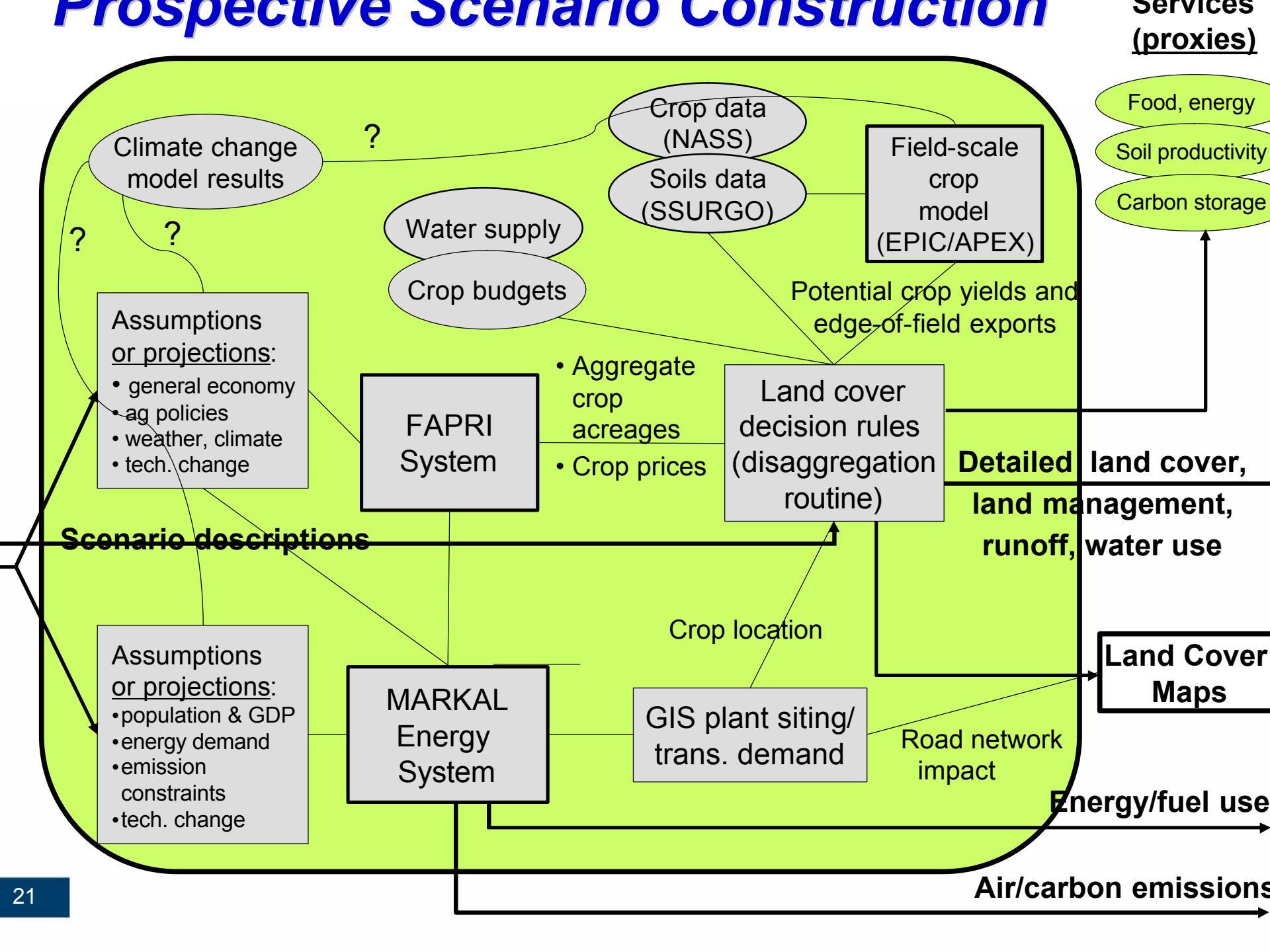
And MODIS crop-specific phenological signatures to identify what crops are planted where

Example of cropping detail available from National Agriculture Statistical Survey (NASS) and university partnership (ISU) for current conditions – State of Iowa



Courtesy of Silvia Secchi, ISU, 2007

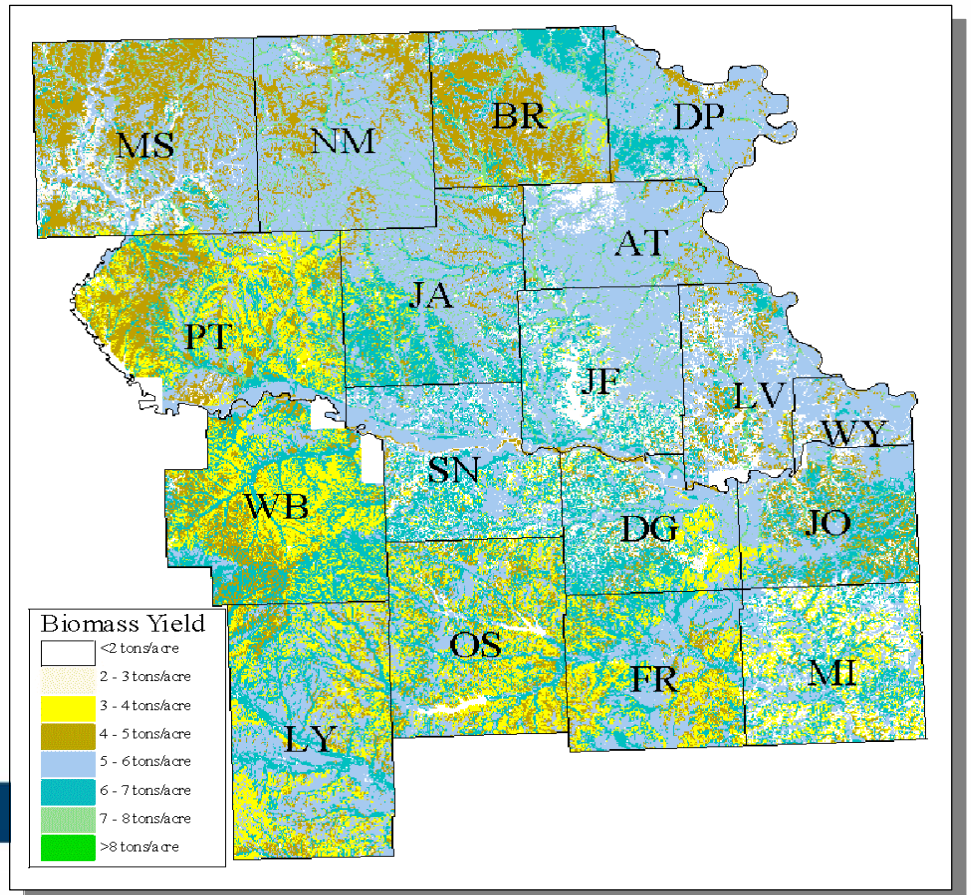
Prospective Scenario Construction



Example of GIS Rules for Projecting Future Scenarios based on FAPRI / MARKAL output

- Remove protected areas and other land use categories that will not change
- Identify existing corn-based ethanol plants and radii for obtaining feedstock
- Identify probable locations for future ethanol plants and feedstock areas based on siting requirements and predicted crop yields
  - Transportation network
  - Soil characteristics
  - Other restricted areas (lakes, streams, buffers)

Scenario Construction: Anticipatory Design or "Targeting" Example



Switchgrass Yields NE Kansas – by individual soil type

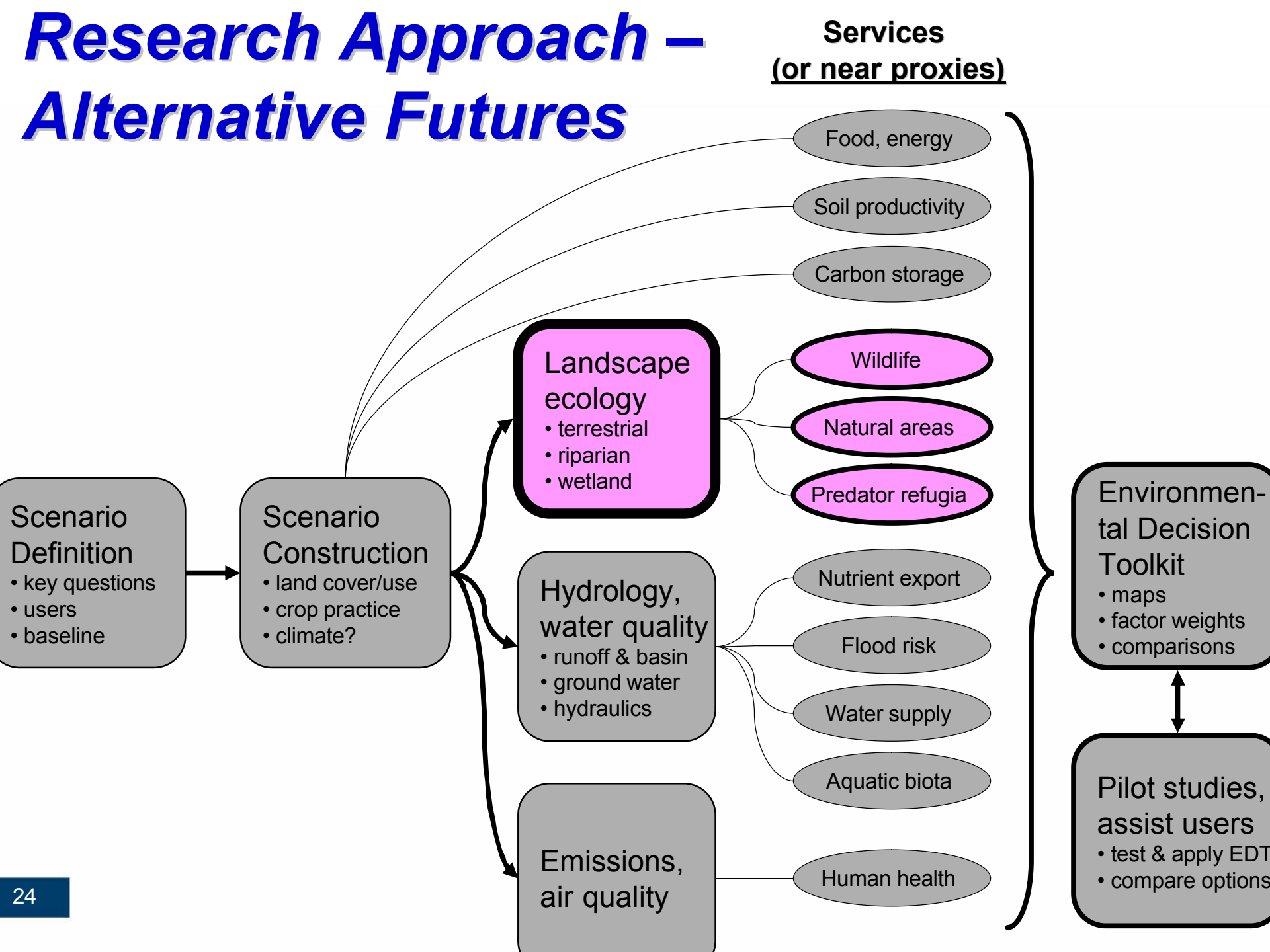
Combine NREL and KSU analysis approaches to estimate:

- **soil erosion**
- **nutrient transfer**
- **carbon flux**

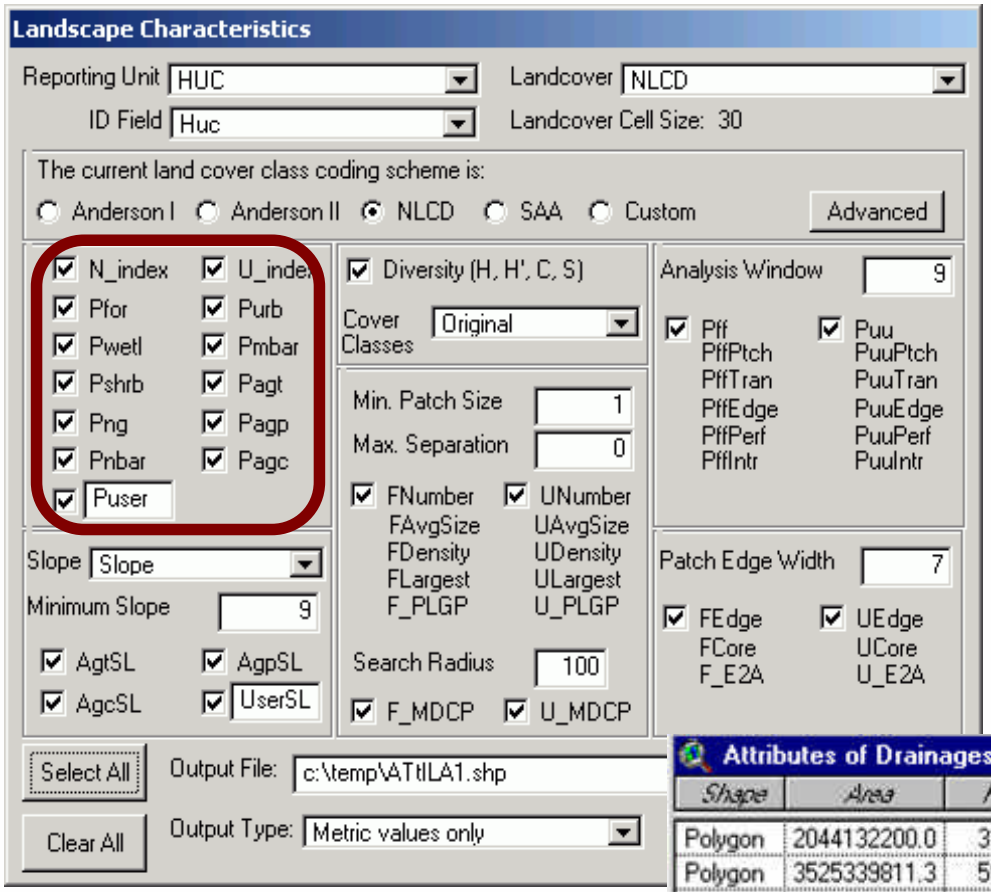
Use for selective targeting of lands for sustainable biofuels development

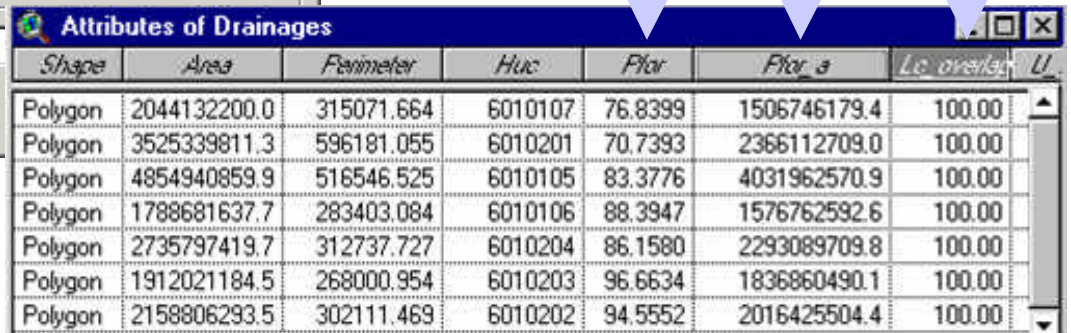
Courtesy Richard Nelson, Kansas State Univ.

Research Approach – Alternative Futures



Analytical Tools Interface for Landscape Assessment - ATtILA





Shape	Area	Perimeter	Huc	Pfor	Pfor_a	Lc_overlap	U_
Polygon	2044132200.0	315071.664	6010107	76.8399	1506746179.4	100.00	
Polygon	3525339811.3	596181.055	6010201	70.7393	2366112709.0	100.00	
Polygon	4854940859.9	516546.525	6010105	83.3776	4031962570.9	100.00	
Polygon	1788681637.7	283403.084	6010106	88.3947	1576762592.6	100.00	
Polygon	2735797419.7	312737.727	6010204	86.1580	2293089709.8	100.00	
Polygon	1912021184.5	268000.954	6010203	96.6634	1836860490.1	100.00	
Polygon	2158806293.5	302111.469	6010202	94.5552	2016425504.4	100.00	

Single Variable Landscape Metrics

- Percentage of crop land
- Percentage of pasture
- Percentage of all Ag use
- Percentage of barren
- Percentage of forest
- Percentage of urban
- Percentage of wetland

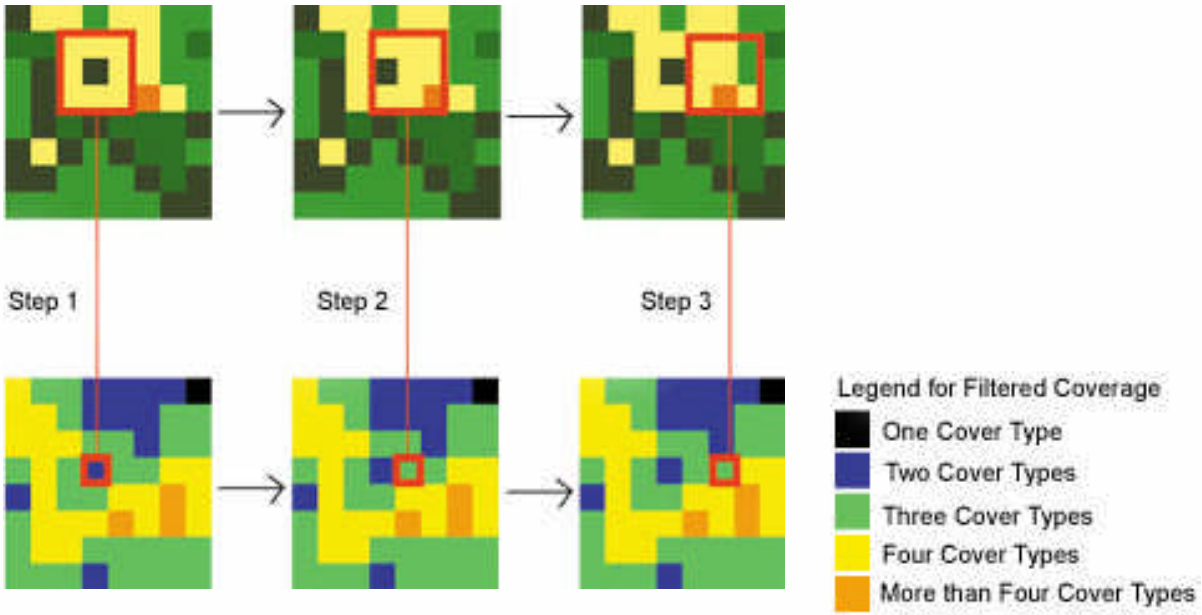
Landscape Ecology: the basics of metrics

We should not expect that other organisms perceive the world in human terms.

The "game" is to specify a filter function that has ecological meaning.

A simple example:

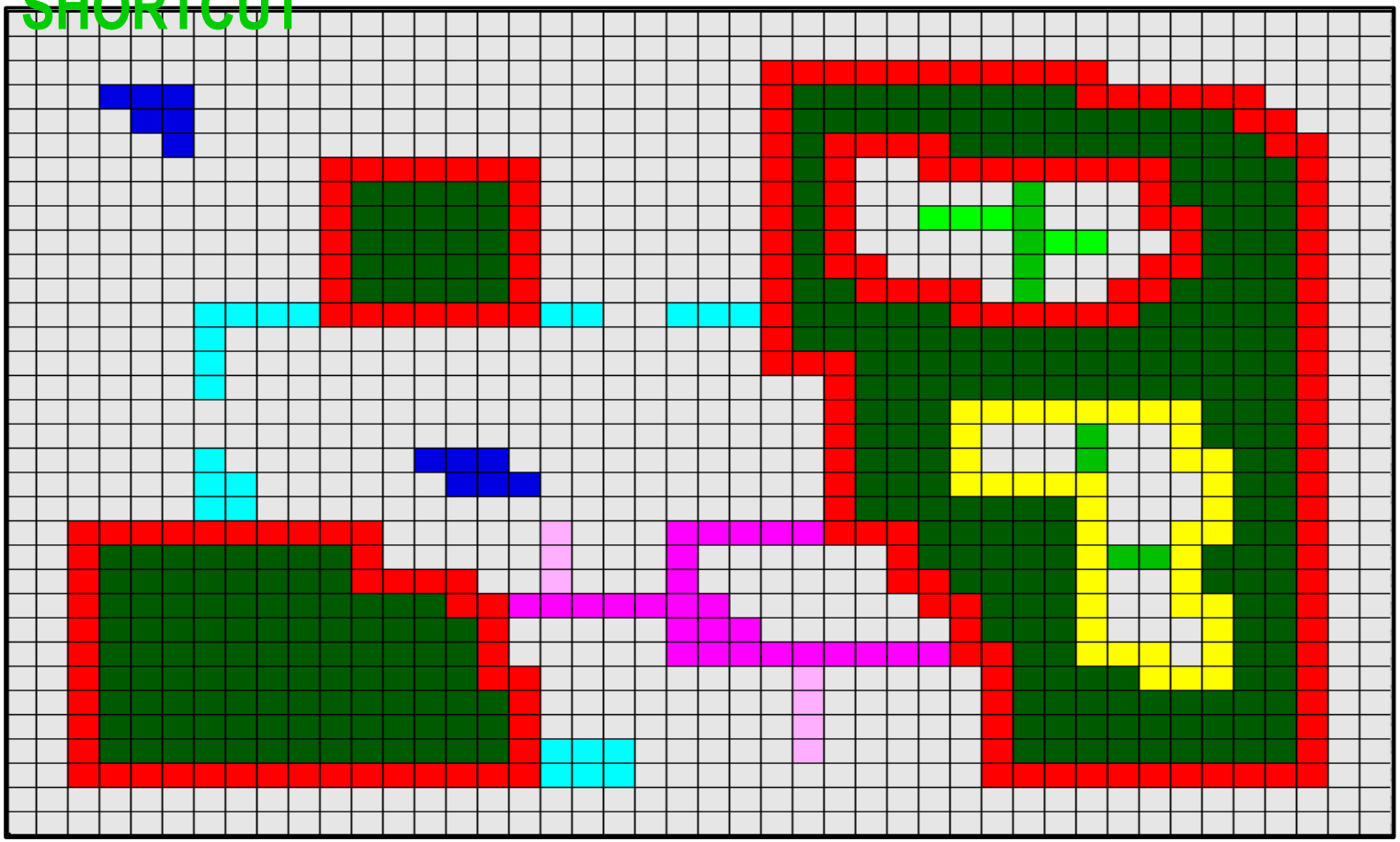
Input = Land-Cover Map



Output = "Diversity" Map

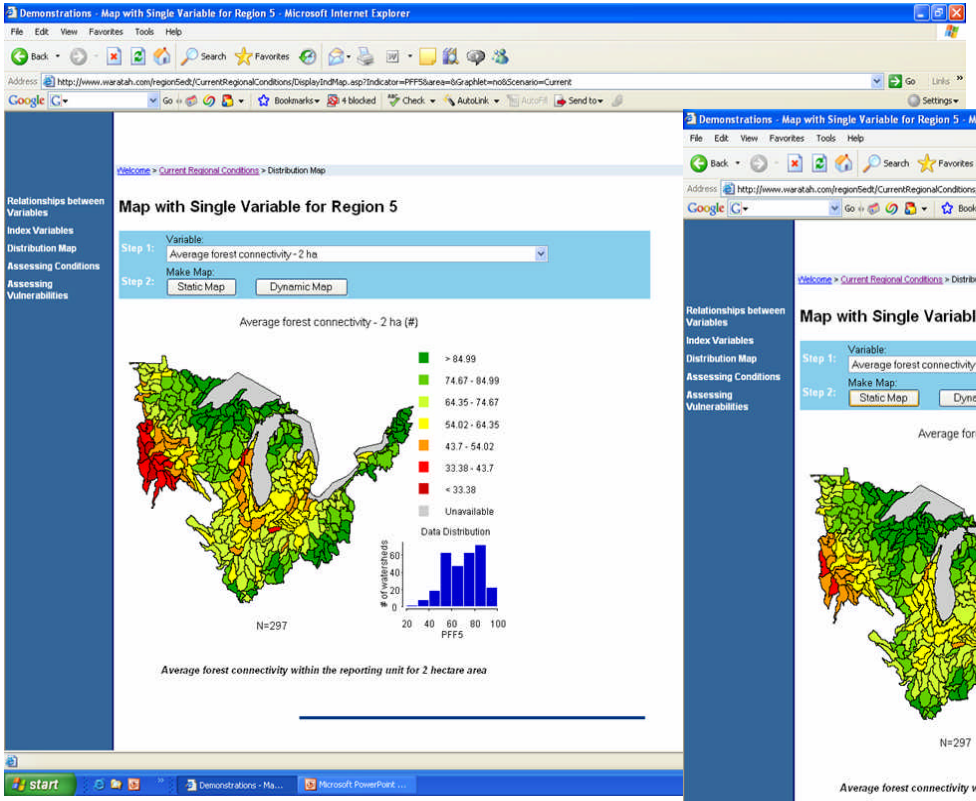
spatial pattern (SP) / connectivity

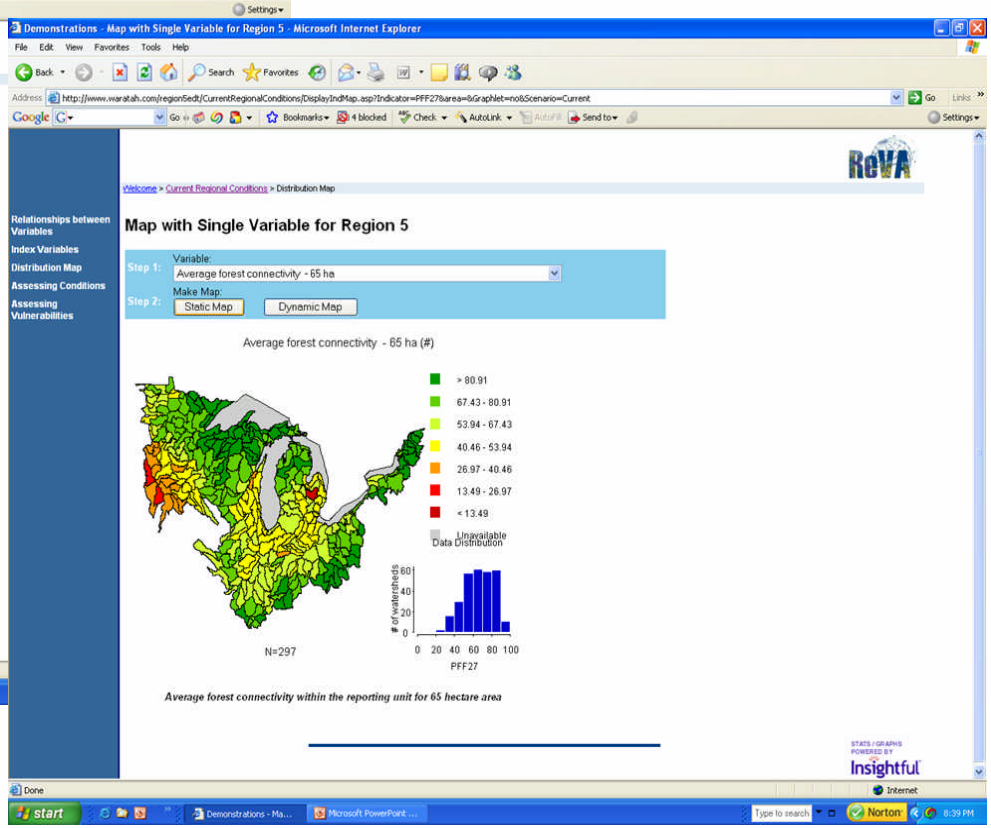
CORE PATCH EDGE PERFORATED CORRIDOR SHORTCUT



BRANCH: - OF EDGE - OF CORRIDOR - OF

ReVA MW-EDT: *Forest Connectivity*

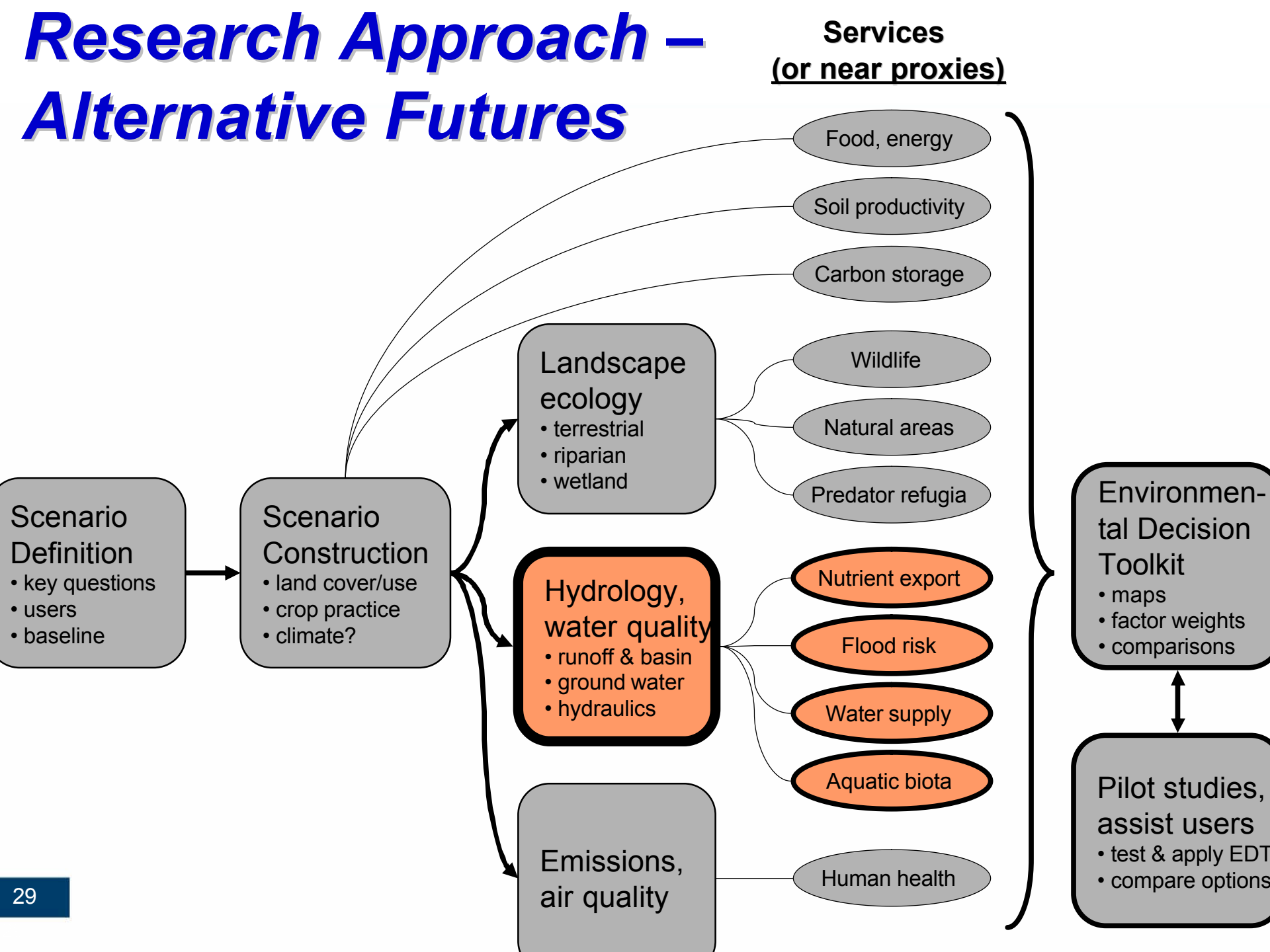




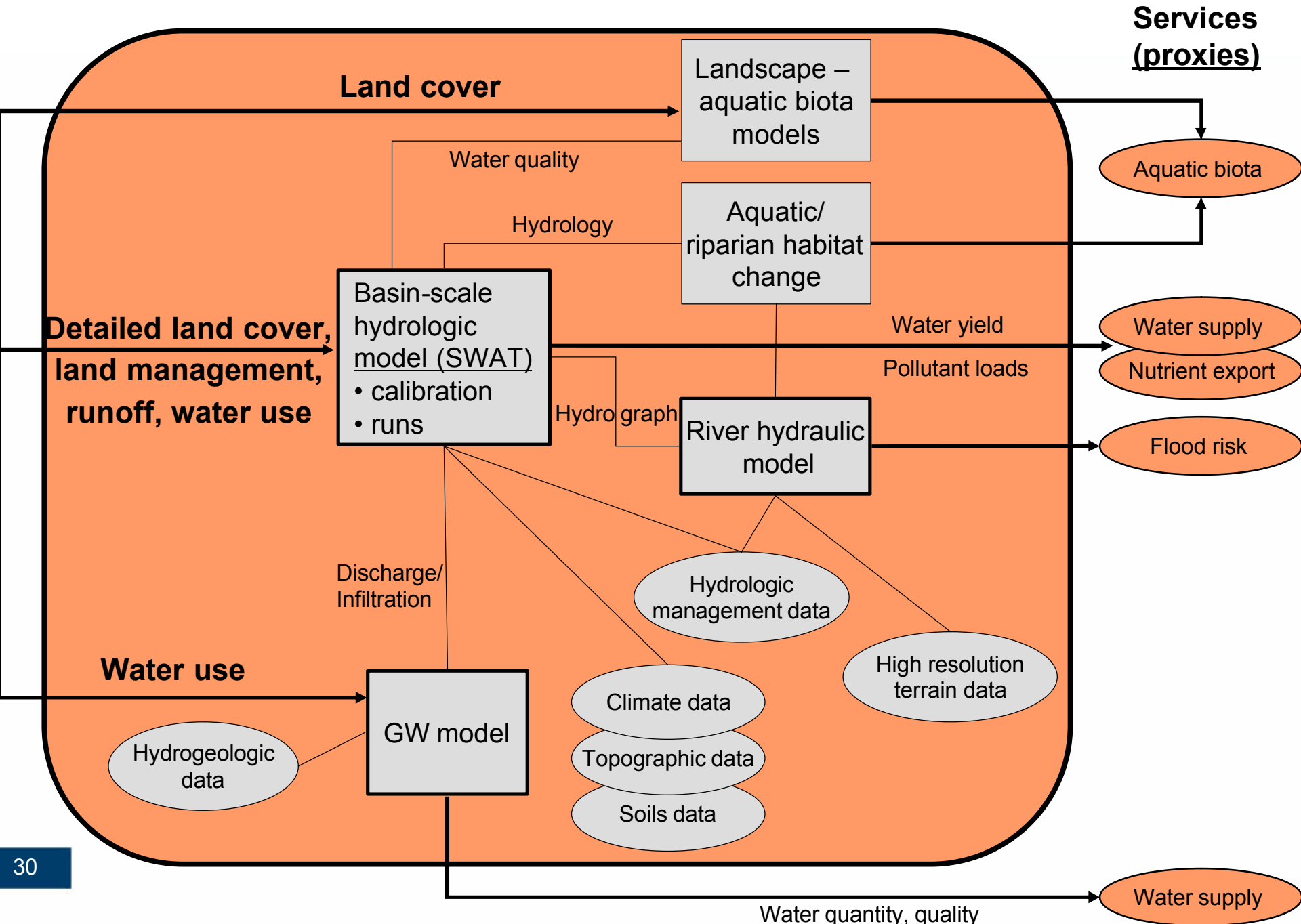
For Migratory Species with Small Ranges

For Migratory Species with Large Ranges

Research Approach – Alternative Futures



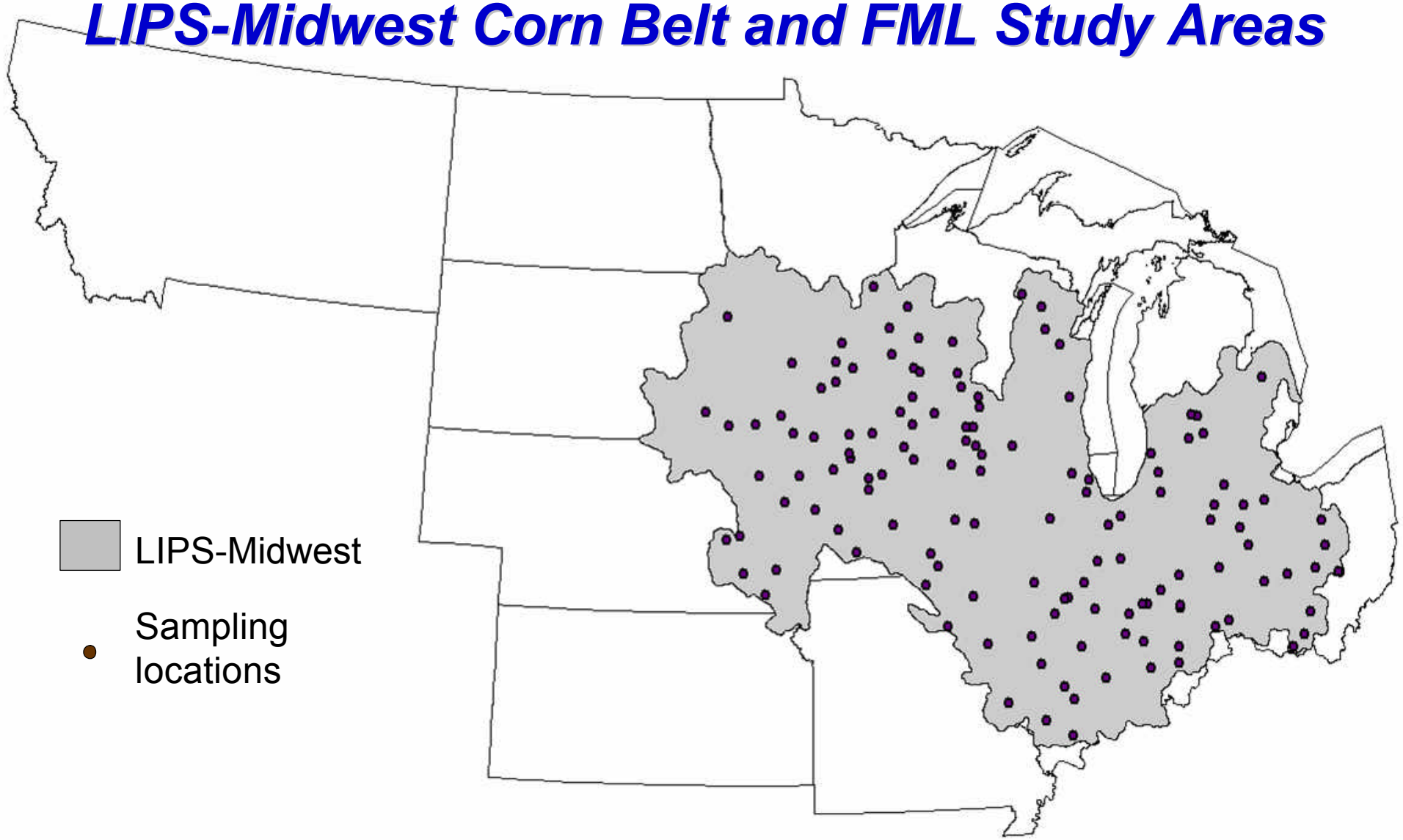
Scenario Analysis: Hydrology, Water Quality



Scenario Analysis: Quantifying Ecosystem Services through Ecological Research

- Tracing applied ^{15}N through an agricultural watershed (NERL/EERD)
- Correlations of wetland landscape characteristics and aquatic ecosystem services (NERL/ ESD and EERD)
- Eco services of restored wetlands in Iowa (NRMRL/LRPCD, NERL/EERD, USGS, R7, OWOW)
- Indices of aquatic ecosystem functions and exposures (NERL/EERD)

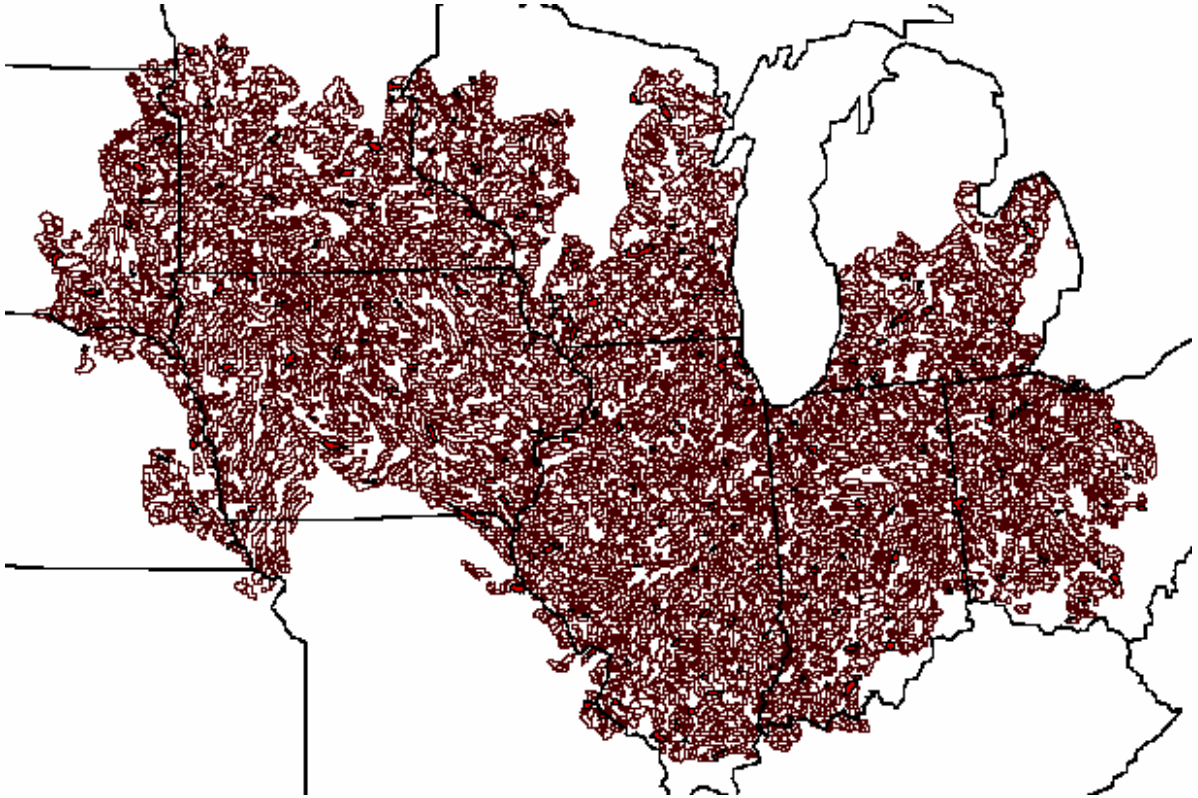
LIPS-Midwest Corn Belt and FML Study Areas



Corn/Soy production on non-irrigated, glaciated soils

LIPS Midwest Corn Belt Study

Synthetic Third Order Watersheds



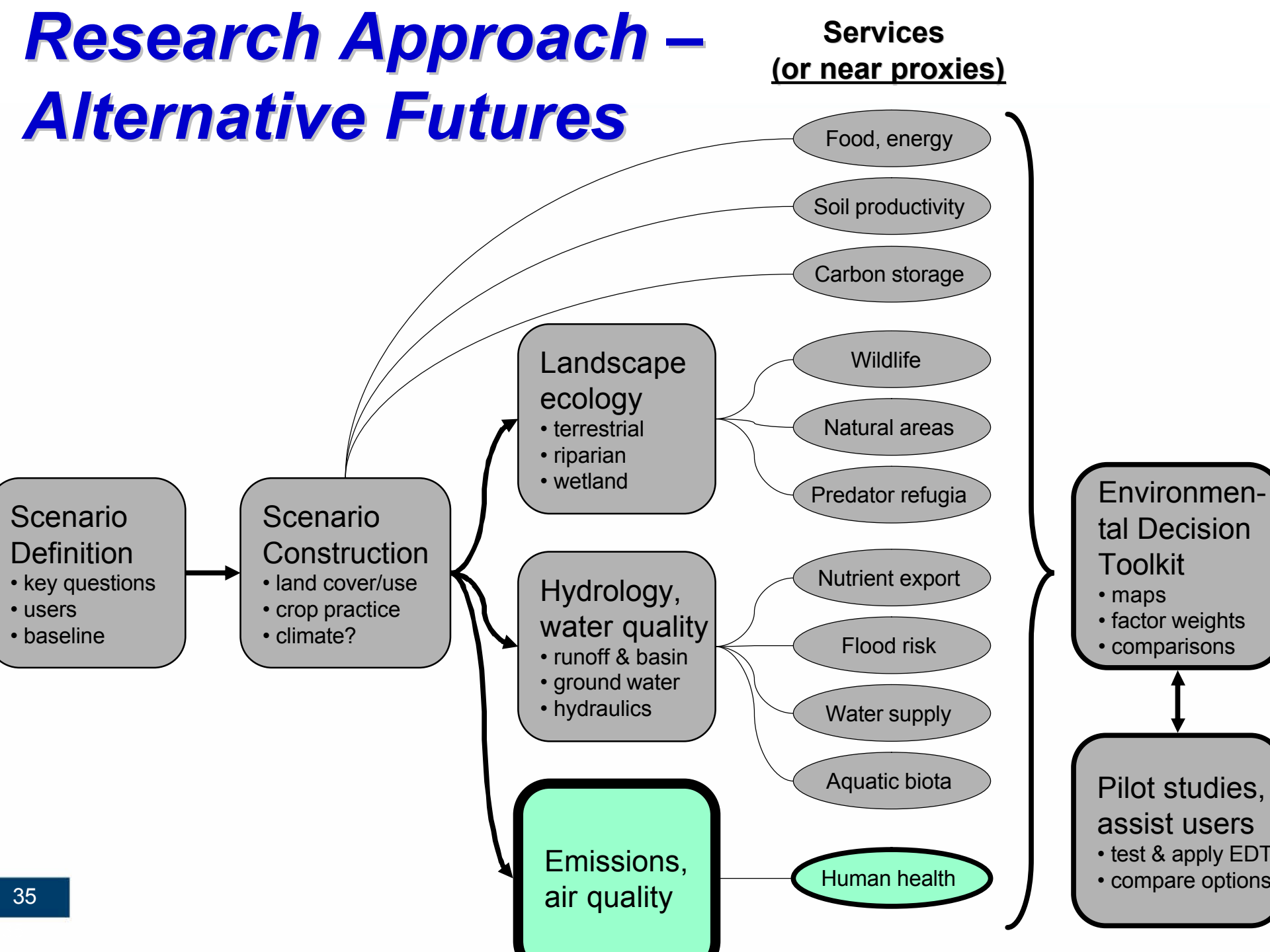
Target population: 6,648 third-order watersheds

Sites represent a uniform distribution across a gradient of agricultural intensity

Base flow streams integrate the watershed

Wetland Reserve Program – Restored Iowa Wetlands

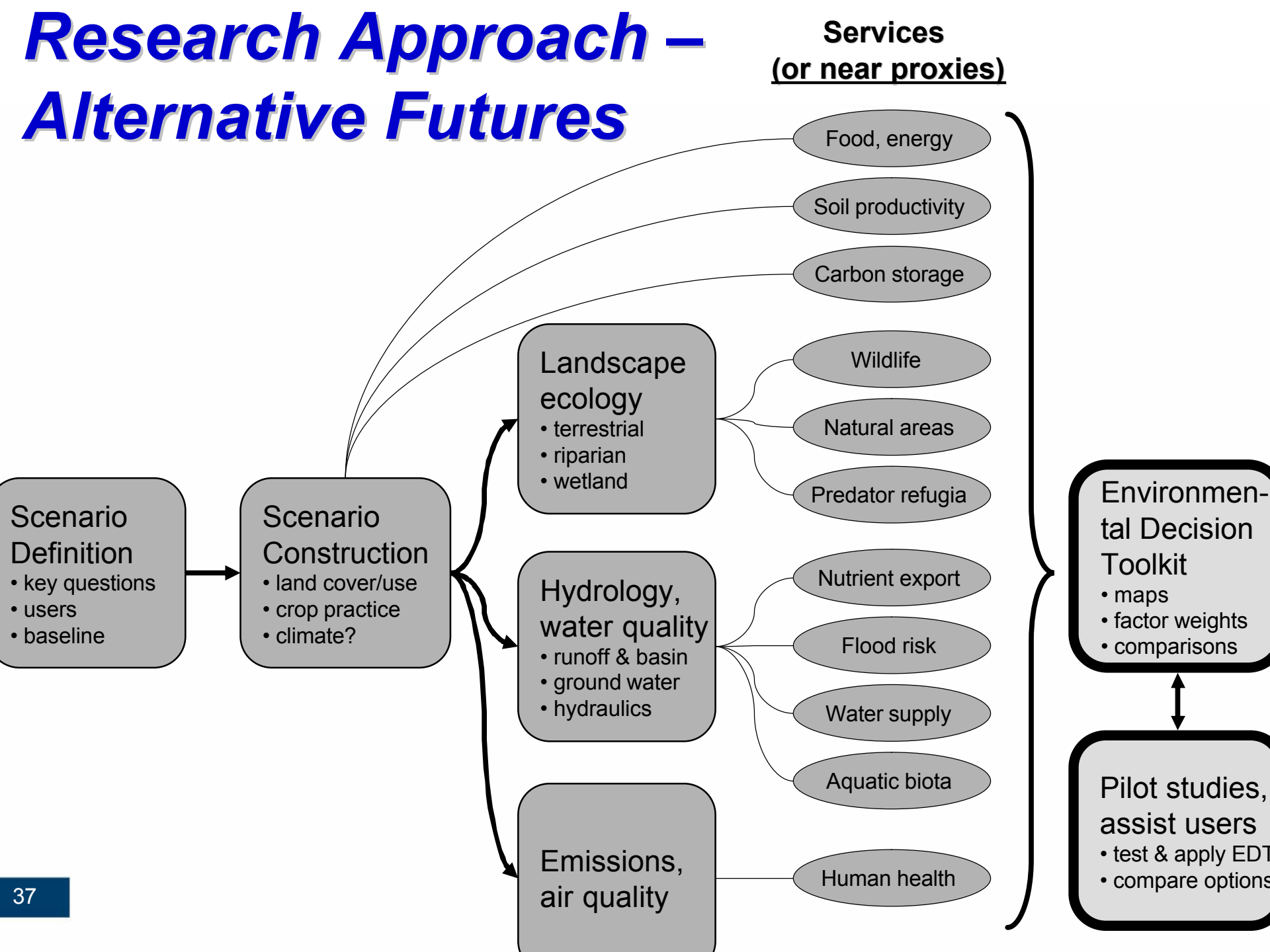
Research Approach – Alternative Futures



Community Multiscale Air Quality (CMAQ) Model

- MARKAL → CMAQ coupling
- direct emissions changes from biofuel supply chain
- indirect emissions changes from offsetting use of other fuels and shifting patterns of fuel demand

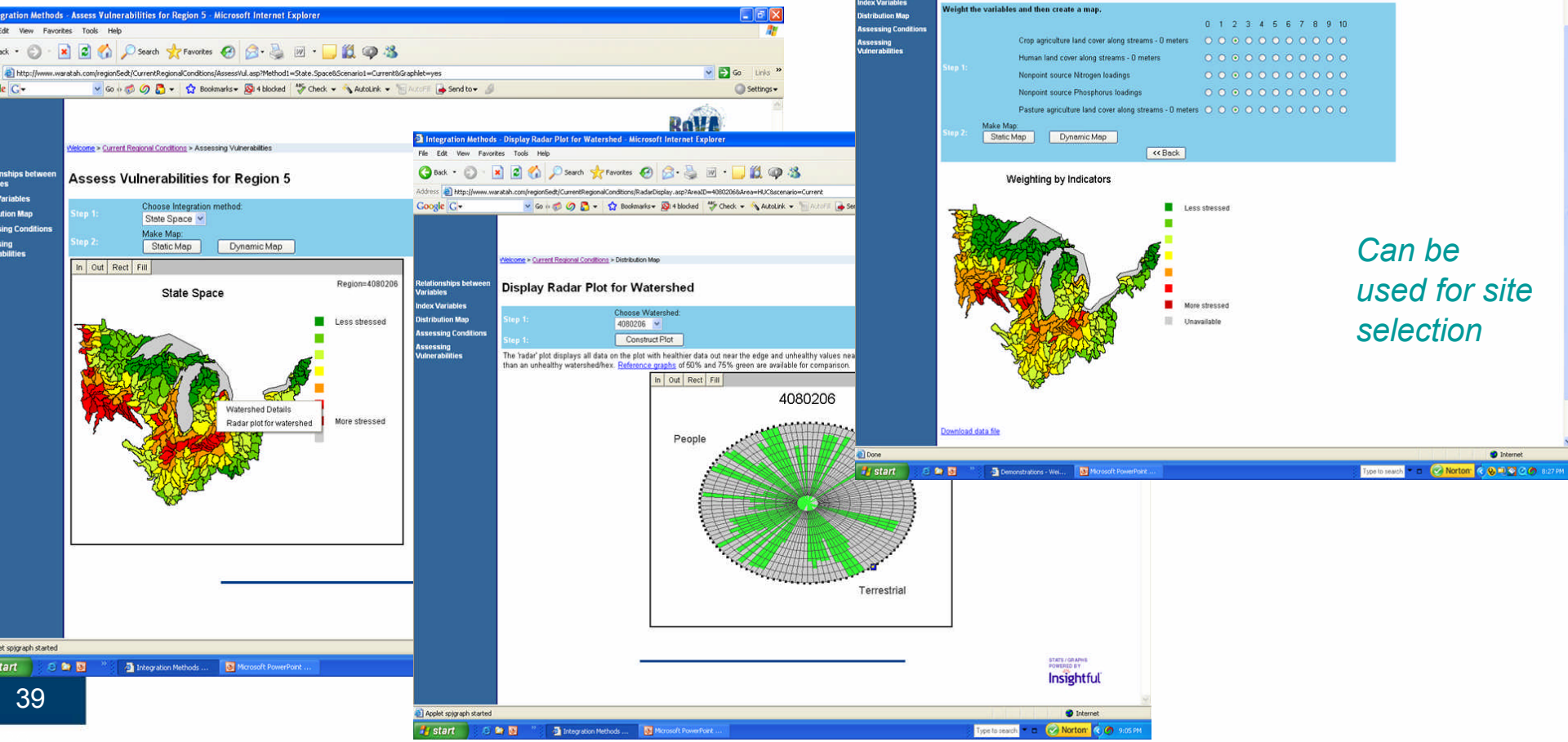
Research Approach – Alternative Futures



Scenario Assessment and Risk Management: Integrating Scenario Outcomes to Address Management Questions

- Cost-benefit analysis or cost-effectiveness analysis
- Visualization of trade-offs using normalized values, qualitative values
- Multicriteria Decision Analysis framework allows use of both quantitive and qualitative values

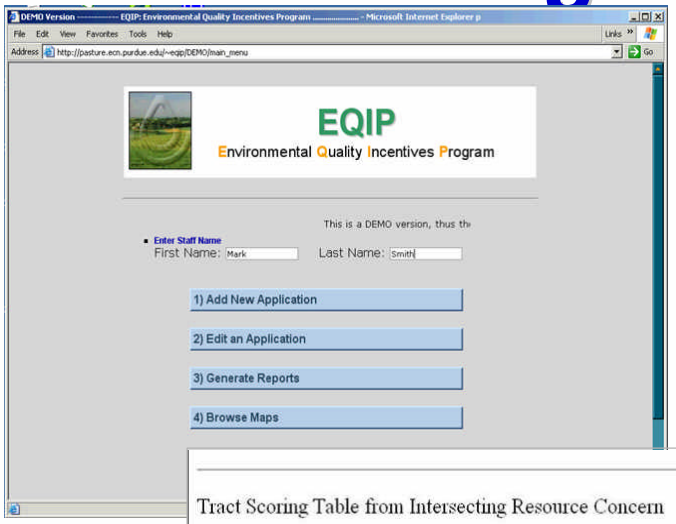
Scenario Assessment and Risk Management: Regional Scale Tool, the MW-EDT



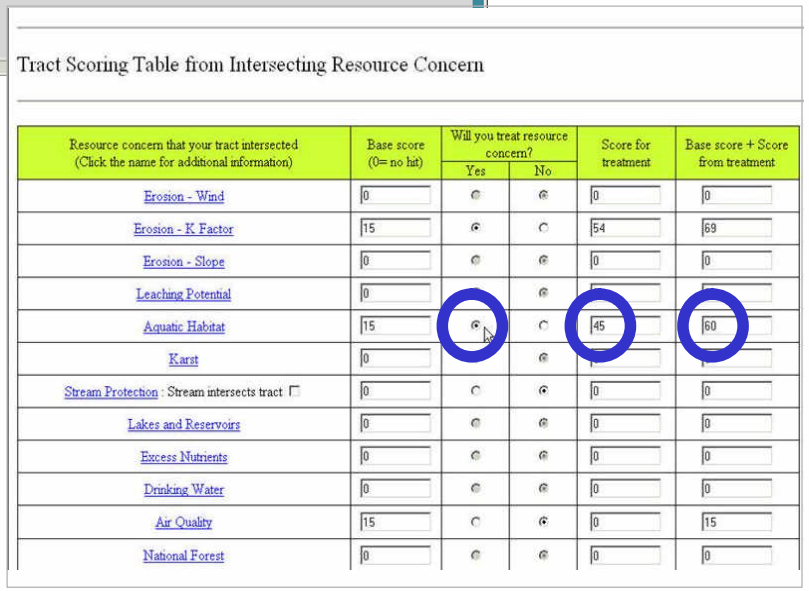
Can be used for site selection

Scenario Assessment and Risk Management: Local-Scale Management Tools

Profitability Analysis



MCDA



FML Design & Implementation Teams

- Scenario selection & specification team
  - Clarify client/user information needs
  - Clarify stakeholder values
  - Identify feasible number of scenarios – seek buy-in
  - Specify scenarios to meet modelers' needs
- Model & data integration team
  - Complete information network diagram
  - Identify best models for the task (start with hydrologic/WQ)
  - Clarify data availability and spatiotemporal compatibility
  - Oversee modeling effort

Design & Implementation Teams

- Scenario-to-service scoping team
  - Conduct conceptual walk-through of all scenarios
  - Estimate sign and magnitude of all service changes
  - Generate hypotheses, guide model-integration
- Ecological research team
  - Pre-proposals
    - Show feasibility
    - Tie to services and FML goals, products
    - Get appropriate collaborators (e.g., NRCS, ARS)
  - Full proposals (QA)
  - Study execution

Design & Implementation Teams

- User case-study team
  - Identify 1 – 3 eager stakeholders
  - Clarify their specific information and decisional needs
  - Write up as preliminary case studies
  - Consult on EDT design needs
  - Work with stakeholders to use FML findings in risk management decisions

To join the FML Study…

- Contact us
  - **Randy Bruins** **bruins.randy@epa.gov** **513-569-7581**
  - **Betsy Smith** **smith.betsy@epa.gov** **919-541-0620**
  - **Brenda Groskinsky** **groskinsky.brenda@epa.gov** **913-551-7188**
- Join a Design and Implementation Team (or two)
- Attend the upcoming FML Team WORKING Meeting
  - Attendance preferred but not required!
  - Nov. 27 – 29
  - Region 5 offices, Chicago

Today's key messages

1. Midwestern landscapes are changing rapidly due to biofuels development, and different futures appear to offer different eco service profiles
2. FML Study will engage stakeholders, conduct relevant analyses and provide online tools
3. Alternative-futures is our study approach
4. Our implementation structure will make it easy for you to get involved

EPA

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ECOLOGICAL RESEARCH PROGRAM

BUILDING A SCIENTIFIC FOUNDATION FOR SOUND ENVIRONMENTAL DECISIONS

U.S. Environmental Protection Agency
Office of Research and Development